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Title: Genetic algorithm for nuclear data evaluation

Author(s): Arthur, Jennifer Ann

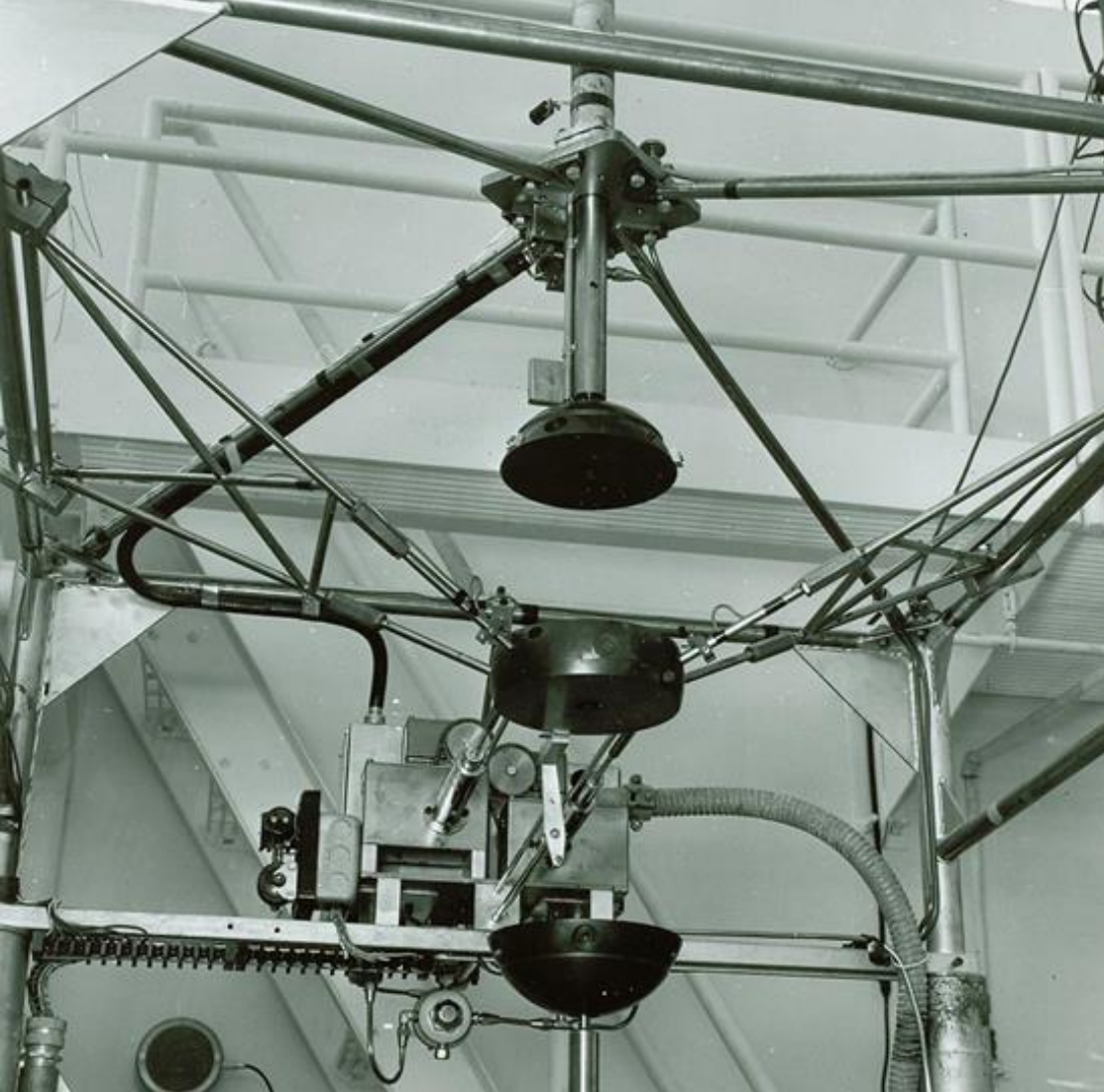
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# Genetic algorithm for nuclear data evaluation

Jennifer Arthur

# Initial population

- Normally sample  $\mu$ ,  $\sigma$  using uncertainties around the mean N times

- $$P = \begin{bmatrix} \mu_1, \sigma_1 \\ \mu_2, \sigma_2 \\ \dots \\ \mu_N, \sigma_N \end{bmatrix}$$

- Each row of **P** is a member in the population
  - There are N members total in the population

# Fitness (outer loop)

- Ideal is fitness=0
- $FF = \sum \frac{C-E}{E}$  , summed over all configurations of all experiments
- Each member of the population has a value of FF (fitness function) assigned to it
- Convergence criteria is that min(FF), which is associated with the most fit member of the population, stops changing more than a certain amount (i.e., 1%)
  - This means that the fittest member of the population is not getting much more fit from generation to generation

# Calculate fitness

- **My proposed method:**
- **Input original (C-E)/E values and original  $\mu$ ,  $\sigma$  values**
- **Also input sensitivities such as:**  $\frac{d\left(\frac{C-E}{E}\right)_{R_1}}{d\mu}$ 
  - These sensitivities are each specific to a single configuration of a single experiment

# Selection (1<sup>st</sup> part of inner loop)

- **N times, pick 2 parents and have them reproduce**
  - This creates the next generation of N members
  - There is no limit to how many times a single member can be a parent
- **Pick random # between min(FF) and max(FF)**
  - I.e., the # can be anywhere from the FF value of the most fit member of the population to the FF value of the least fit member of the population
- **1<sup>st</sup> 2 members that have  $FF \leq \text{random \#}$  are the parents**
  - After randomizing population vector of course
- **This makes it so that more fit members of the population are more likely to be chosen, but even members with the worst fitness still have a chance to reproduce**



## Reproduction (2<sup>nd</sup> part of inner loop)

- **Crossover with mutation probability**
- **Reproduce by averaging the  $\mu$  and  $\sigma$  values of each of the parent pairs chosen in the selection step**
- **Each time an average is taking, there is a 1% chance that a random value is picked instead of the average**
  - Random value (“mutated” value) is generated the same way the initial population was generated

# Solution

- **The optimized solution is the member of the population that has the minimum (best) value of FF at the time of convergence of the minimum value of FF**

# Example

- **N=100**
- **Using real  $\mu$ ,  $\mu$  unc.,  $\sigma$ ,  $\sigma$  unc., and (C-E)/E inputs**
- **Made-up sensitivities (of (C-E)/E values to a change of a single unc.):**
  - $R_1$  to  $\mu$  : .01
  - $R_2$  to  $\mu$  : .001
  - $M_L$  to  $\mu$  : .001
  - $R_1$  to  $\sigma$  : .001
  - $R_2$  to  $\sigma$  : .01
  - $M_L$  to  $\sigma$  : .01

Mutation rate: 10%

Convergence criteria: .1%

# Example

- **Original FF=1.8144**
  - Original nuclear data: 3.182, 4.098
- **New FF=1.2742**
  - New nuclear data: 3.1815, 4.0795